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A. V. Prudnikov, master's degree student (BSTU);
M. M. Revyako, D. Sc. (Engineering), professor (BSTU);
E. Z. Khrol, PhD (Engineering), senior lecturer (BSTU); **A. F. Petruşhenya**, assistant lecturer (BSTU)

INFLUENCE OF THE STRUCTURE OF THE ADHESIVE COMPOSITION ON THE PROPERTIES OF LAMINATED WOOD PLASTICS

The results of tests of layered wood plastics on the basis of a birch veneer and thermoplastic adhesive compositions based on polyvinyl acetate and polyurethane are presented in the article. The basic advantages and disadvantages of such layered wood plastics and separate components of composite materials are described here. Moreover, the possibility of separate components characteristics modifying by the use of turbohardener and moisture resistant impregnating substance for the purpose of improving of characteristics of all composite material as a whole is proved in the article. Besides, advantages which can be achieved by such modifying of components and possible application spheres of the wood plastics made from such components and possessing higher performance are analyzed in the work.

Introduction. Recently, in the Republic of Belarus a great attention has been paid to the development of a wood working industry. Products of this branch are widely used in many fields of human activities, in particular transport, furniture and interior elements manufacturing, construction and so on. The raw materials used in this industry are polymeric materials which are used in composite materials based on wood fillers as adhesives.

One of the ways of increasing the effectiveness of enterprise work in wood-processing industry is the improvement of gluing process of wood materials. Therefore, of particular importance is improvement and modification of the adhesive material the costs of which account for approximately 30–40% of the total production costs of such products based on wood fillers as plywood. Adhesive properties define operational and consumer properties of laminated wood plastics.

In Belarus, the sphere of production of polymeric materials is underdeveloped, and therefore it is not able to satisfy all the needs of the domestic market. Many domestic manufacturers of wood laminates have to buy adhesives for the production of such composites abroad. Such factors as the scarcity of raw materials and a high level of its cost also greatly hamper the development of the sphere of production of glued furniture parts.

Recently, the country implements a program aimed at import substitution of various products in different sectors of the economy. Therefore the development of more effective compositions of adhesives that can be used in the production of wood-based plastics, is quite promising and in future will allow domestic enterprises to reduce their dependence on expensive imported raw materials and possibly to reduce production costs of their products.

Main part. For a long time in the production of wood laminated plastics thermal reactive materials have been used as a polymeric adhesive composition. But these polymers contain in its structure such harmful chemical substances such as formaldehyde, phenol and etc. In this connection, recently, many manufacturers have begun actively using adhesives based on thermoplastic materials, which are characterized by much less toxicity to humans. Furthermore, these materials have significantly lower adverse effects on the environment [1, 2].

Adhesives based on polyvinyl acetate (PVA) are widely used in the woodworking industry. The disadvantage of such materials over a long period of time was their insufficient high water resistance. In case if the products containing similar polymer are used in conditions of increased humidity, with the passage of time, they can be destroyed as a result of the joint opening. Scientists have carried out many studies in which various gluing (linking) compounds were introduced into adhesive compositions, which resulting in materials based on the PVA with improved water resistance. In addition, other polymers, such as polyurethanes may be used as an adhesive in such materials [3, 4].

In this work, the authors have studied plywood (wood laminated plastics based on the wood veneer), which is characterized by high strength and moisture resistance.

In the manufacture of plywood , the authors have used the birch wood veneer and adhesives based on polyurethane and polyvinyl acetate mark Kleiberit (Germany), namely polyurethane adhesive Kleiberit 501, polyvinyl acetate-based adhesive Klebit 303, as well as such modifiers as turbohardener 303.5 (TH) and moisture resistant impregnating substance Kleiberit 555.6 [5–7].

The advantage of adhesives based on PVA is that the use of a hardener is not required when they are used to achieve high strength of laminating the individual layers of the composite and therefore such adhesives possess almost unlimited viability and rapidly cure at ambient or elevated temperature. Curing of such adhesives occurs due to the removal of moisture and chain growth of the macromolecules. The disadvantage of this type of adhesives is their low heat resistance (up to 40–

60°C), high fluidity under load and decreased water resistance. Despite these shortcomings PVA dispersion currently are the most suitable, environmentally friendly adhesives, which are used for the manufacture of many items of furniture and joinery products used indoors. The curing time of these polymers at 20°C is 15–30 minutes, the adhesive providing a completely colorless seam [5, 8].

In this work performance characteristics of adhesive compositions were evaluated according to the characteristics of the laminated plastics obtained by means of them. Thus, in particular, such properties of composite materials as water absorption (state standard specification SSS 9621), shear strength (SSS 9624), ultimate tensile strength (SSS 9622) were estimated.

The results of testing samples of plywood produced by using studied adhesives for water absorption are shown in Table 1. The research has revealed that the use of the impregnating substance in the adhesive composition can reduce water absorption of the composite material approximately twice, i. e. it is possible to minimize the main disadvantage of mentioned adhesive. Due to the introduction of turbohardener into the adhesive composition based on polyvinyl acetate the class of gluing D4 is provided, which in its turn provides a high moisture-resistance of the adhesive seam. Consequently, the product would not undergo delamination at prolonged exposure to moisture. This greatly improves the performance properties of the plywood and can increase its quality. Plywood with such improved performance can be used in the manufacture of more responsible products, in particular those which can directly contact with moisture when used.

Results of tests of samples of plywood on shear are shown in Table 2. From these results, it is evident that the strength properties of developed wood plastics exceed the minimum value by 3–10 times (depending on the adhesive composition), and hence the material meets all the requirements for this type of products. Increased ultimate strength of plywood on shear allows to use such material in the manufacture of loaded furniture elements. Furthermore, by increasing the strength characteristics of the plywood the articles of smaller size can be manufactured (while keeping a constant level of strength characteristics), which allows to reduce the consumption of materials and products, and as a result, the cost of their production.

Test results on shear strength of plywood samples glued with PVA glue Klebit 303 depending on the temperature and amount added turbohardener and PU adhesive KLEIBERIT 501 are shown in Tables 3 and 4.

Table1

Results of studies on determination of water absorption of the test samples in accordance with SSS 9621

The composition, used as the adhesive	Sample weight before wetting, g	Sample weight after wetting, g	Water consumption, %
Klebit 303 + 4% TH	1.78	2.86	60.6
Klebit 303 + 4% TH + the impregnating substance of Kleyberit 555.6	2.03	2.75	35.4
Kleiberit 501	1.84	2.68	45.6
Kleiberit 501 + the impregnating substance of Kleiberit 555.6	1.80	2.33	29.4

Table 2

The results of tests to determine shear strength of the tested plywood glued samples SSS 9624

The structure of the composition used as the adhesive	Ultimate strength, MPa
Klebit 303 + 4% TH	4.17
Klebit 303 + 4% TH + the impregnating substance of Kleiberit 555.6	7.79
Kleiberit 501	9.06
Kleiberit 501 + impregnating substance of Kleiberit 555.6	14.00

Table 3

Test data to determine the tensile strength of tested glued plywood samples SSS 9622

Structure of the composition used as the adhesive	Turbohardener, wt %	Tensile stress, MPa at a molding temperature, °C	
		50	80
Klebit 303	0	3.73	3.10
	1	3.26	3.10
	2	3.74	3.53
	3	2.74	2.71
	4	3.20	4.57
	5	4.00	3.58
		40	60
Kleiberit 501	0	3.68	4.10

Table 4

The results of tests to determine tensile strength of the tested samples of glued plywood impregnated with a moisture resistant material KLEIBERIT 555.6, according to SSS 9622

Structure of the composition used as the adhesive	Turbohardener, wt %	Tensile stress, MPa at a molding temperature, °C	
		50	80
Klebit 303	0	3.15	4.09
	1	4.10	4.08
	2	3.07	3.31
	3	4.75	3.67
	4	5.39	4.64
	5	3.28	4.13
		40	60
Kleiberit 501	0	3.81	5.40

On the basis of research results, we can conclude that samples based on PVA of glue Klebit 303 with addition of 4% of turbohardener and samples based on PU glue KLEIBERIT 501 obtained at a pressing temperature of 80°C possess the maximum shear strength. Later, mentioned above compositions were studied in more detail. It was also established that the use of the impregnating substance of KLEIBERIT 555.6 practically increases durability of glue joint approximately by 25%.

Conclusion. In research we have studied the composition of materials based on polyurethane and polyvinyl acetate adhesive of brand KLEIBERIT (Germany), in which turbohardener and moisture resistant impregnating agent were added. The resulting samples were subjected to breaking, chipping and water absorption tests.

A study of the degree of change in the physical and mechanical properties during the tensile test revealed that due to the introduction of 4% turbohardener into the PVA glue one can achieve maximum bonding strength compared to single-component PVA glue. In tests on chipping it has been found that the use of polyurethane glue gives the value of the adhesive joint strength in 6 times greater than the minimum admissible and the use of PVA glue with 4% turbohardener – 2 times higher than the minimum admissible value of strength.

Thus, in the work, it was found that by modifying the adhesive composition, provided you use veneer with the same properties, plywood with higher performance can be obtained. This plywood has a number of characteristics that allow its use in some new spheres of application, in particular in the production of furniture elements which can be used under the direct impact of environmental moisture, stronger car interiors elements, etc. A number of modified polymeric compositions which can be used as an adhesive for gluing the separate layers of wood plastic were examined in the work. The composite material proposed in the work can be used in the following areas:

– for obtaining products with both the elevated and with the standard performance, including the products of unique structure;

– veneering of material in order to improve their aesthetic appearance and to increase their durability;

– obtaining of large size products;

– maintenance and restoration of products and etc.

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